

Western Electric Co., Incorporated,  
Engineering Dept.,  
New York.

(1 Page) Page #1.  
Appendix 1.  
Issue 5 - BT-431156.  
February 18, 1922.

METHOD OF OPERATION  
FINAL CIRCUIT

With Marginal Relay Test - Full Mechanical Switching System.

Page 8: The circuit requirements have been changed as follows:

THE READJUST REQUIREMENTS SHOWN BELOW ARE FOR MAINTENANCE USE ONLY

	<u>OPERATE</u>	<u>NON-OPERATE</u>	<u>RELEASE</u>
E527	Special requirements to insure fast release.		
(L)	Readj. .015 amp.	Readj. .010 amp.	Hold:
Inner Wdg.	Test .016 amp.	Test .0095 amp.	Readj. .011 amp.
(1000 ohms) W.C.C.	.0185 amp.		Test .012 amp.
			W.C.C. .013 amp.

Outer Wdg. Test .041 amp.  
(500 ohms) W.C.C. .086 amp.

E547	Special requirements to insure fast release.	
(T)	Readj. .048 amp.	Readj. .039 amp.
Outer Wdg.	Test .051 amp.	Test .037 amp.
(400 ohms)		W.C.C. .017 amp.

Inner Wdg.	Test .015 amp.	Test .0036 amp.
(900 ohms) W.C.C.	.048 amp.	

NOTE: 1 - This relay shall be equipped with a removable armature stop (piece part 163914).

Spl.E9	Special requirements to meet circuit conditions.	
per	Armature Travel .020" $\pm$ .0025".	
D-20876	Readj. .0254 amp.	Readj. .0215 amp.
coded	Test .0268 amp.	Test .0205 amp.
E551	W.C.C. .0268 amp.	W.C.C. .0164 amp.
(PBX)		
E565	Readj. .017 amp.	Readj. .011 amp.
(TK)	Test .019 amp.	Test .010 amp.
	W.C.C. .021 amp.	

E1383	Special requirements to insure fast operation.	
(TB)	Armature Travel shall be .015" $\pm$ .0025".	
	Readj. .0062 amp.	Readj. .001 amp.
	Test .0065 amp.	Test .0009 amp.
	W.C.C. .012 amp.	

ENG.--JLS:ML.  
2/28/22.

CHK'D.--WJT:OMP.

APPROVED - C. I. SLUYTER, G.M.I.

RECEIVED  
JAN 10 1964  
U.S. DEPARTMENT OF AGRICULTURE  
WASHINGTON, D.C.

TO: DIRECTOR, AGRICULTURAL RESEARCH SERVICE  
FROM: [illegible]  
SUBJECT: [illegible]

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Replacing all previous issues.  
March 15, 1921.

#### METHOD OF OPERATION

Schematic - For - Final Circuit - With Marginal Relay Test - Full Mechanical Switching System.

#### GENERAL DESCRIPTION

1. This circuit is used as a final selector in a full mechanical switching office. It is selected by a local, cordless, office, or inter-office incoming selector.
2. The principal functions of this final selector are as follows:
  1. To select the desired line and establish talking connection.
  2. To test the line for busy.
  3. If the line is idle to hold it busy to other hunting selectors.
  4. If the line is busy to give a busy back signal to the calling party.
  5. To select a non-busy line in a P.B.X. group.

#### DETAILED DESCRIPTION

##### OPERATION

3. When an incoming selector seizes the tip, ring and sleeve terminals of this circuit, ground from the incoming circuit is connected to the sleeve terminal as a busy condition. At the same time a circuit is closed advancing the incoming selector to its "Selection Beyond" position. This circuit is traced from ground on cam I, upper inner contact of cam J, outer winding of the T relay, lower inner and upper outer contacts of cam N, over the ring conductor, to battery through the winding of the incoming line relay.

4. The T relay does not operate at this time due to the high resistance in the circuit. After the associated incoming selector circuit has advanced, a circuit is closed from battery through the inner winding of the L relay, lower inner contact of cam G, upper inner contact of cam F, tip side of the trunk, to ground through the stepping relay in the associated sender circuit, operating the L relay. The operation of the L relay closes a circuit from ground on its armature, through the lower inner contacts of cams E and D, to battery through the winding of the TK relay which operates. The TK relay operated, (a) locks to ground on the sleeve conductor, and (b) advances the switch to position 2 in a circuit from ground on its armature, upper outer contact of cam C, to battery through the R magnet.

##### BRUSH AND GROUP SELECTION

5. The L relay operated, (a) locks in a circuit from battery through the inner winding and make contact, lower outer contact of cam G, over the fundamental circuit, previously described, and (b) closes a circuit from ground on its armature, inner contacts of cam E, to battery through the HS magnet which operates, causing the selector to move upward for brush selection. As the selector moves upward in position 2, carrying the commutator brushes over the commutator segments, the A segment and brush intermittently connect ground to the tip side of the fundamental circuit, through cam F,

successively short circuiting the stepping relay in the associated sender circuit, thus releasing it and permitting its re-operation until the proper brush has been selected. When sufficient impulses have been sent back to satisfy the sender, the fundamental circuit is opened, releasing the L relay. The L relay released, opens the circuit through the HS magnet, stopping the upward movement of the selector, and closes a circuit from ground through its armature, and break contact, upper outer contact of cam B, to battery through the R magnet, advancing the switch to position 3. In position 3, the TRIP (TM) magnet operates to ground on cam I. In position 3, the fundamental circuit is again closed operating the L relay. The L relay operated, locks through its inner winding, over the fundamental circuit and advances the switch to position 4, in a circuit from ground on its armature, cam B, to battery through the R magnet. In position 4, the HS magnet operates to ground on the armature of the L relay, moving the selector upward for tens selection. The trip magnet being operated in position 3 to 5, causes the previously selected set of brushes to trip as the selector starts upward in position 4. As the selector moves upward for tens selection carrying the commutator brushes over the commutator segments, the B segment and brush intermittently connect ground to the tip side of the fundamental circuit, through cam G, successively short circuiting the stepping relay in the associated sender circuit, thus releasing it and permitting its re-operation, until the proper group has been selected. When sufficient impulses have been sent back to satisfy the sender, the fundamental circuit is opened, releasing the L relay. The release of the L relay, (a) opens the circuit through the HS magnet stopping the brushes at the selected group and (b) closes a circuit through the R magnet which advances the switch to position 5. In position 5 the L relay again operates and locks over the fundamental circuit as described for position 1. The operation of the L relay advances the switch to position 6.

#### UNIT SELECTION

6. In position 6, a circuit is closed from ground on the armature and make contact of the L relay, through cam E, and the upper inner contact of cam D, to battery through the LS magnet which operates, moving the selector upward for units selection. The U commutator brush and segment, in units selection, function the same as described for the A commutator brush and segment during brush selection. When sufficient impulses have been sent back to satisfy the sender the fundamental circuit is opened, releasing the L relay. The L relay released, advances the switch to position 7. In position 7 the fundamental circuit is again closed operating the L relay. The L relay operated advances the switch to position 8, the A cam advancing the switch to position 9. When the switch enters position 7-3/4 to 9 the holding circuit through the inner winding of the L relay is transferred from the tip side of the fundamental circuit to ground on the lower outer contact of cam I. The T relay operates in position 9 in a circuit from battery through the inner contacts of cam K, outer winding of the T relay, lower contacts of cam E, to ground on the armature of the L relay. The T relay operated, advances the switch to position 10 in a circuit from ground on cam I, lower inner contacts of cam J, make contact of the T relay, lower outer contact of cam B, to battery through the R magnet, the A cam advancing the switch to position 11. The L relay releases as the switch leaves position 9.



#### INDIVIDUAL LINE OR FIRST LINE OF A P.B.X. GROUP NOT BUSY

7. Ground on the armature and back contact of the L relay advances the switch to position 12. If the sleeve brush is resting on the terminal of an idle individual or P.B.X. line when the switch leaves position 9, the T relay releases. With the T relay released and the switch in position 12, a circuit is closed from ground through the lower inner contacts of cams I and J, break contact of the T relay, lower inner contact of cam B, to battery through the R magnet, advancing the switch to position 13, the A cam advancing the switch to position 14. When the switch enters position 13, a circuit is closed from ground through the armature and break contact of the L relay, upper outer contact of cam B, to battery through the R magnet advancing the switch to position 15. In position 15 the tip and ring of the circuit are closed through to the incoming trunk.

#### DISCONNECTION

8. When the associated incoming selector returns to normal, ground is disconnected from the sleeve terminal, opening the holding circuit through the TK relay which releases. The TK relay released, (a) closes a circuit from ground on cam I, to the sleeve terminal, holding the final selector busy to hunting incoming selectors until the switch returns to normal, (b) closes a circuit from ground through its armature, lower outer and upper inner contacts of cam N, to battery through the outer winding of the L relay which operates. The L relay operated advances the switch to position 16. If the receiver has not been replaced on the switchhook at the called station when the switch enters position 15-3/4, the L relay is held operated in a circuit from battery through its inner winding and make contact, outer contacts of cam M, R brush over the ring side of the called line through the sub-station loop, T brush, to ground on the lower outer contact of cam J. In position 16, a circuit is closed from ground through the armature and make contact of the L relay, cam E, upper outer contact of cam D, to battery through the selector alarm circuit which operates if this circuit remains in position 16 for an abnormal length of time. When the receiver at the called station is replaced on the switchhook, the L relay releases, advancing the switch to position 17. With the switch in position 16 a 600 ohm shunt through the lower contacts of cam U, is closed around the inner winding of the L relay, to insure its release against a line leak. In position 17, a circuit is closed from ground through armature and break contact of the TK relay, cam C, to battery through the R magnet, advancing the switch to position 18. In position 18 a circuit is closed from ground on the G commutator brush and segment, lower outer contact of cam D, upper outer contact of cam E, to battery through the DOWN magnet, which operates restoring the selector to normal. When the selector reaches normal, a circuit is closed from ground on the Y commutator brush and segment, through the upper inner contact of cam C, to battery through the R magnet, advancing the switch to normal.

#### INDIVIDUAL LINE BUSY

9. As the switch enters position 9 the T relay operates through its outer winding to ground on the armature and make contact of the L relay. If the sleeve brush is resting on the terminal of a busy individual line when the switch enters position 9, the TB and P.B.X. relays operate in a circuit from ground on cams I and H, through

the windings of the P.B.X. and TB relays, make contact of the T relay, lower inner and upper outer contacts of cam L, to battery on the sleeve terminal of the busy individual line. The TB relay, operated, closes a circuit through the inner winding of the T relay, holding the T relay operated. The switch advances to position 10 in a circuit from ground through the lower inner contacts of cams I and J, make contact of the T relay, and lower outer contact of cam B, to battery through the R magnet, the A cam advancing the switch to position 11. The L relay releases as the switch leaves position 9. The operation of the P.B.X. relay opens the circuit through the winding of the L relay, thus preventing the L relay from operating as the switch passes through position 10. In position 11, a circuit is closed from ground on the armature and break contact of the L relay, upper outer contact of cam B, to battery through the R magnet, advancing the switch to position 12. In position 12, the L relay operates in a circuit from ground through the lower inner contacts of cams I and J, make contact of the T relay, lower inner contacts of cams F and G, to battery through the inner winding of the L relay. The L relay operated, advances the switch to position 13, the A cam advancing the switch to position 14. The TB and P.B.X. relays release as the switch leaves position 13. The L relay operated in position 12 locks through its inner winding and make contact, to ground on cam I. In position 14 a circuit is closed from ground on the armature and make contact of the L relay, lower inner and the upper outer contacts of cam E, to battery through the DOWN magnet which operates, restoring the selector to normal. When the selector reaches normal, the switch is advanced to position 17 in a circuit from ground on the Y commutator brush and segment, to battery through the R magnet. The L and T relays release as the switch leaves position 14. In position 17, a circuit is closed from ground through the contacts of the busy back interrupter, inner contacts of cam O, outer winding of the T relay, to battery through the inner contacts of cam K, alternately operating and releasing the T relay. The operation of the T relay in position 17, on Full Mechanical calls connects an interrupted busy tone through the lower contacts of cam L to the ring side of the trunk which is transmitted to the calling party. On calls through a cordless B board 48 volt battery on cam K is closed through one contact of the T relay to the tip side of the incoming trunk for flashing the "A" operator's supervisory lamp. When the receiver is replaced on the switchhook at the calling station and the associated incoming selector returns to normal, the TK relay releases. The release of the TK relay restores the switch to position 1 as described under "Disconnection".

ONE OR MORE BUT NOT ALL LINES OF A P.B.X. GROUP BUSY

10. If the sleeve brush is resting on the sleeve terminal of a busy P.B.X. line when the switch enters position 9, a circuit is closed from ground on the lower inner contacts of cams I and H, windings of the P.B.X. and TB relays make contact of the T relay, lower inner and upper outer contacts of cam L to battery on the sleeve terminal of the busy P.B.X. line. The TB relay operates in this circuit, closing the circuit through the inner winding of the T relay, holding the T relay operated, but the P.B.X. relay does not operate at this time due to the high resistance of the P.B.X. sleeve circuit. The switch advances to position 10 as described under "Individual Line Busy" the A cam advancing the switch to position 11. In position 10 a circuit is closed from ground on the lower inner contact of cam J, break contact of the P.B.X. relay, inner contacts of cam G, to battery through the inner winding of the L relay which operates. The L relay operated, closes a circuit from ground on its armature, cams E and D to battery through the LS magnet, moving the selector upward over the P.B.X. terminals.



When the sleeve brush makes contact with the sleeve terminal of an idle P.B.X. line, and breaks contact with an idle line the circuit through the P.B.X. and TB relays is opened, and these relays release, opening the circuit through the inner winding of the T relay. The T relay does not release immediately due to a circuit being closed from ground on the C commutator brush and segment, cam O, outer winding of the T relay, inner contacts of cam N, to battery through the outer winding of the L relay. The L relay is also held operated in this circuit. The LS magnet therefore remains operated and the selector continues to travel upward until the brushes are carried slightly above the center of the line terminal, allowing the pawl to enter the notch on the rack attached to the elevator. At this time, the holding circuit, through the outer winding of the T relay is opened at the C commutator releasing the relay. The T relay released, releases the L relay. The L relay released, opens the holding circuit through the LS magnet, allowing the elevator to drop into place, thus centering the brushes on the line terminals. The release of the L relay also advances the switch to position 12. In position 12 ground on the armature and break contact of the T relay, advances the switch to position 13, the A cam advancing it to position 14. Ground on the armature and break contact of the L relay advances the switch to position 15. From this point on the circuit functions as described above.

NOTE:- The adjustment of the C commutator brush, with relation to the tripped sleeve multiple brush, is such, that it does not break contact with the C commutator segment until slightly after the sleeve brush leaves the busy terminal and makes contact with the sleeve terminal of the idle line. The LS magnet, therefore, remains operated under control of the L and T relays and the selector continues to travel upward until the brushes are carried slightly above the center of the line terminals, allowing the pawl to enter the notch on the arc attached to the brush support rod. At this time the holding circuit through the outer winding of the L and T relays is opened at the C commutator, releasing the relays. The L relay released releases the L.S. magnet, allowing the elevator to drop into place, thus centering the brushes on the trunk terminals. During P.B.X. hunting the commutator feed ground is supplied through cam D, from ground on the armature of an under control of the L relay. This to prevent the re-operation of the L relay on the overthrow of the selector or as it drops into place.

#### ALL LINES OF A P.B.X. GROUP BUSY

11. If all the lines of a P.B.X. group are busy, the selector continues upward in position 11. When the sleeve brush makes contact with the sleeve terminal of the last line of the group the P.B.X. relay operates. The P.B.X. relay operated, opens the circuit through the L relay which releases, and advances the switch to position 12. From this point on the circuit functions the same as described under "Individual Line Busy".

#### TELL TALE

12. When the selector travels to the top of the frame in position 2, 4 or 6, a circuit is closed from ground through the X commutator brush and segment advancing the switch to position 7. In position 7, the L relay operates over the fundamental circuit advancing the switch to position 8, the A cam advancing it to position 9. The L relay operated in position 7, locks through its inner winding and make contact when the switch enters position 7-3/4 to ground on cam I. In position 9, the T relay operates in a circuit from battery through the inner contacts of cam K through the outer winding of the T relay, lower contacts of cam E to ground on the armature of the L relay. The T relay operated, advances the switch to position 10 from ground on the lower inner contact of cam J, the A cam advancing the switch to position 11. When the switch leaves position 9, the L relay releases. In position 11 ground through the X commutator brush and segment advances the switch to position 12. When the switch leaves position 9 the T relay releases. In position 12 ground through the lower inner contact of cam J, the break contact of the T relay and the lower inner contact of cam B advances the switch to position 13, the A cam advancing the switch to position 14. In position 14 ground through the armature and break contact of the L relay advances the switch to position 15. The switch remains in position 15 until the associated incoming selector advances releasing the TK relay. The release of the TK relay closes a circuit from ground through its armature and break contact, to the sleeve terminal, holding this circuit busy to other hunting incoming selectors, until this circuit has advanced to normal. The release of the TK relay also closes a circuit from ground through its armature and break contact, lower outer and upper inner contacts of cam N to battery through the outer winding of the L relay which operates and advances the switch to position 16. When the switch leaves position 15-1/2, the L relay releases. In position 16 ground through the armature and break contact of the L relay advances the switch to position 17. Ground through the armature and break contact of the TK relay advances the switch to position 18. In position 18 ground through the upper outer contact of cam H, lower outer contact of cam D, upper outer contact of cam E, to battery through the down magnet moves the selector downward. When the selector reaches normal, a circuit is closed from ground through the Y commutator advancing the switch to position 1.

#### PREMATURE RELEASE

13. If the receiver at the calling station is replaced on the switchhook any time before the switch has advanced from position 13, the associated incoming selector returns to normal, opening the holding circuit for the TK relay, which releases. The release of the TK relay closes a circuit from ground through the upper inner contact of cam I, to the sleeve terminal holding this circuit to other busy hunting incoming selectors until the switch has returned to normal. The release of the TK relay also advances the switch to position 14. In position 14, ground through the armature and break contact of the L relay, advances the switch to position 15.



In position 15, the L relay operates in a circuit from ground through the break contacts of the TK relay, and advances the switch to position 16. When the switch leaves position 15-1/2, the circuit through the outer winding is opened, releasing the relay. The release of the L relay advances the switch to position 17. In position 17, ground through the armature and break contact of the TK relay and the lower outer contact of cam C advances the switch to position 18. In position 18, the down magnet operates over the circuit previously described, moving the selector downward. When the selector reaches normal, a circuit is closed from ground through the "Y" commutator brush and segment advancing the switch to position 1 or normal.

#### P.A.X. DIALING

14. When P.A.X. dialing is required, the circuit has been so arranged that ground through the upper outer contact of cam J is connected to the ring side of the circuit in positions 3 to 14-1/2. When the circuit is wired for P.A.X. dialing, the incoming selector is held in its "Selection Beyond" position by ground through the outer winding of the T relay in parallel with the B-1 and B-2 resistances, through positions 1 to 3 of the final, and then from ground on cam J through positions 3 to 14-1/2 as explained above.

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CIRCUIT REQUIREMENTS

OPERATE

NON-OPERATE

RELEASE

E527 (L) Test .016 amp.  
Inner Wdg. Readj. .015 amp.

Test .0095 amp.  
Readj. .010 amp.

Hold:  
Test .012 amp.

Outer Wdg. Test .042 amp.

E547 (T) Test .049 amp.  
Outer Wdg. Readj. .046 amp.

Test .029 amp.  
Readj. .031 amp.

Hold:  
Test .012 amp.

Inner Wdg. Test .016 amp.

Test .0075 amp.

Sp1. E9 Test .0268 amp.  
per Readj. .0254 amp.

Test .0205 amp.  
Readj. .0215 amp.

D-20876

Coded

E551

(P.B.X.)

E565 Test .019 amp.  
(TK) Readj. .017 amp.

Test .010 amp.  
Readj. .011 amp.

E1383 Test .0065 amp.  
(TB) Readj. .0062 amp.

Test .0009 amp.  
Readj. .001 amp.

ENG.---CAL-VL.  
9/2/31.

CHK'D---RAP.

APPROVED - C. L. SLUYTER, G.M.L.